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Prospects for biodiesel production from *Macrotermes nigeriensis*: Process optimization and characterization of biodiesel properties

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ABSTRACT

The use of insects as feedstock for biodiesel production has sparsely been studied and very little is known of the fuel properties and engine performance of insect biodiesel. In this study, biodiesel was initially produced from an insect feedstock *M. nigeriensis*, then its physicochemical properties were characterized. The biodiesel was produced via the three-step process of lipid extraction, acid esterification (1 wt% H_2SO_4) and alkaline transesterification (0.5 wt% NaOH). The optimal reaction time, temperature and methanol-oil molar ratio for the acid-esterification process resulted in a free fatty acid conversion of 96.58%. The volumetric yield, fatty acid methyl esters content and physicochemical properties of *M. nigeriensis* biodiesel were analyzed using various analytical equipment such as the GC-HRMS, and ^{1}H NMR. Analysis of the production process showed that 86.54 vol% biodiesel was obtained from *M. nigeriensis* oil. Further analysis showed that the biodiesel contained 96.72% fatty acid methyl esters. The composition of the fatty acid methyl esters was found to be 48% saturated esters and 52% monosaturated esters. The biodiesel density (841 kg m^{-3}), viscosity (2.32 mm^2 s^{-1}), flash point (125 °C), pour point (−15 °C), cetane number (51.4), higher heating value (41.8 MJ kg^{-1}) and acid value (0.44 mgKOH.g^{-1}) were in compliance with the ASTM D6751 standards. One of the important results to highlight is the remarkably low viscosity of the biodiesel, which is attributed to the high concentration of monounsaturated fatty acid methyl esters. Lower viscosity of fuel helps to improve fuel atomization and combustion efficiency, and hence lower emissions. The absence of polyunsaturated fatty acid esters also indicates that the biodiesel will have good oxidation stability.

1. Introduction

The crises of escalating fuel price [1] and environmental degradation have begun to pose serious problems to the sustainable development and industrialization of economies of many countries [2–4]. One of the fall-outs of these problems is the search for renewable energy sources that meet international standards on engine emissions and engine performance [5,6]. To this end, most of the methods for controlling diesel engine emissions have been classified into two groups: the pre-combustion and the post-combustion control methods [6]. One of the pre-combustion methods for controlling diesel engine emissions required the use of oxygenated fuels such as biodiesel and bioethanol [5]. Biodiesel is considered an alternative to conventional diesel because of its portability, renewability, biodegradability, relatively high cetane number and relatively low sulfur content [3,4,7–9]. Although biodiesel could easily be produced by alkaline-catalyzed transesterification of triglycerides-rich fats and oils [10–12], some of the other methods for biodiesel production include direct blending, micro-emulsification, thermal cracking and catalytic cracking of fats and oils [13,14].

Biodiesel can be produced from oils derived from edible crops (soybean oil, palm oil, rapeseed oil, sunflower oil, peanut oil, etc) and non-edible crops (jatropha oil, stillingia oil, karanja oil, neem oil, castor

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